Name _____

Ecosystems and the Biosphere:
Energy Flow Through the Ecosystem and the Recycling of Matter

Overview: An ecosystem is: _____

_____

All of the organisms living on Earth need _____ to carry out life processes such as growth, movement, and reproduction. In an ecosystem, the ultimate source of energy is the _____. The sun's energy is _____ from one form to another and _____ through the various levels of the ecosystem. The flow of energy through an ecosystem is crucial to the ecosystem's ability to sustain life.

I. Energy Flow Through the Ecosystem

A. Sunlight is the _____.
   1. Without this energy from the sun, _____.
   2. Of all the sun's energy that reaches the earth, less than _____ is actually used by _____.
   3. This 1% is used by the organisms that are capable of _____. Photosynthesis is the process by which _____
      _____
      _____
   4. The organisms on Earth that cannot carry out photosynthesis rely on _____
      _____
      _____
   5. Not only does photosynthesis provide _____ in the form of _____ for many of the organisms on Earth, but it also removes _____ from the atmosphere and releases _____ into the atmosphere.

B. Autotrophs
   1. Autotrophs are organisms that have the ability to _____
      _____
      _____
   2. Autotrophs convert _____
   3. The only organisms that are autotrophs are _____
      _____

4. On land, the _____ are the main autotrophs. In aquatic ecosystems, _____ are the main autotrophs. _____ are also important _____ producers.
5. Autotrophs are also called "_____".
6. The autotrophs are essential to the flow of _____ through the ecosystem.
7. Our very life is _____ on these autotrophs. Without them, we would not have _____
8. A few autotrophs can produce food in the _____. Through a process called _____, these autotrophs use the energy contained in the _____ such as hydrogen sulfide to produce food. Chemosynthesis is a process that is carried out by several types of _____.

C. Heterotrophs

1. Many organisms cannot directly use the energy from the sun as the autotrophs do.
2. These organisms acquire their energy from _____.
3. Heterotrophs are organisms that _____. They rely on other organisms for their _____.
4. Heterotrophs are also called "_____".
5. There are many types of heterotrophs:
   a) Herbivores obtain energy by _____.
   b) Carnivores obtain energy by _____.
   c) Omnivores obtain energy by _____.
   d) Detritivores feed on _____ _____.
      Examples of detritivores are _____.
   e) Decomposers are a class of detritivores that cause _____ _____. Decomposers include _____.
      Some of the molecules released during decay are consumed by the _____, and some of these molecules are returned to _____. The action of the decomposers makes the _____ contained in the dead bodies and wastes of organisms available to _____. The process of decomposition _____.

f) What would happen if there was no decomposition? All life on Earth would _____ as detritus (_____) piled up and the supply of _____ needed to build new _____ was exhausted. Chemical elements such as _____ must be recycled to be used again in new organisms.

D. In summary, _____ enters the _____ in the form of _____. It is converted to _____ energy by _____ and passed to _____ in the form of _____.

II. Feeding Relationships

A. What happens to energy in an ecosystem as one organism eats another?

The energy flows in a _____ path through the ecosystem. Energy enters the ecosystem in the form of _____. Photosynthetic organisms convert the sun's energy into molecules of _____. This energy is then passed on to the animals that eat the plants and to the animals that eat other animals.

B. Energy flows through an ecosystem in _____, from the _____ to _____ and then to various _____.

C. Food Chains

1. The energy stored by producers in the form of glucose molecules can be passed through an ecosystem along a _____.
2. A food chain is _____
   _____
3. All food chains begin with an _____.
4. Examples:
   a) _____
   b) _____

D. Food Webs

1. In an ecosystem, the feeding relationships between organisms are much too complex to be shown in a _____.
2. Many consumers eat _____. More than one species may feed on _____.

3. There are many _____ between many different food chains.
4. Food web _____
   _____
5. A food web links _____ in an ecosystem together.

E. Trophic Levels
1. Each step in a food chain is called a _____. The trophic level indicates _____.
2. The first trophic level in a food chain is always made up of _____. These organisms are referred to as _____.
3. The second trophic level is occupied by the _____ that feed on the _____. These organisms are referred to as _____.
4. _____ belong to the third level. These organisms are referred to as _____.
5. _____
6. Each consumer depends on the _____.
7. Most ecosystems contain only _____ trophic levels.

III. Productivity of the Ecosystem

A. The productivity of the ecosystem can be measured in two ways:
1. _____
2. _____

B. Gross primary productivity:
1. Gross primary productivity is _____
   _____
2. Gross primary productivity is the _____ that is converted to _____ energy by _____ per unit time.
3. The photosynthetic organisms in the ecosystem capture the energy from the _____ and store it in molecules of _____.

C. What does the plant do with the glucose it produces?

1. About _____ of the glucose is used immediately in _____. Respiration is the conversion of _____ _____.
2. Some of the glucose molecules are used as _____ for the building of other _____ compounds within the cell.
3. Much of the glucose is _____.

D. Biomass is a term that is used to describe _____. Producers add biomass to an ecosystem by making _____.

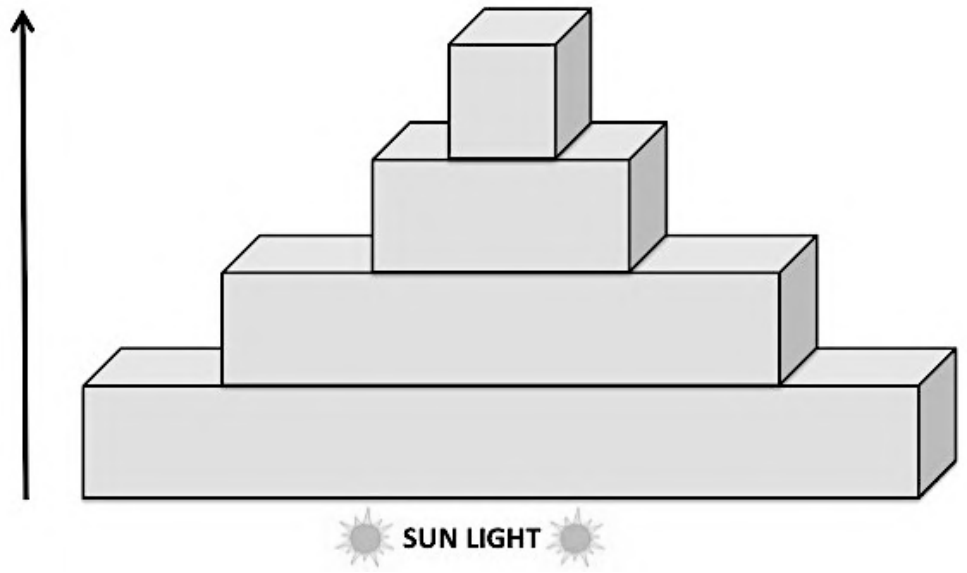
E. Net primary productivity

1. The energy stored as _____ is available to other organisms in the ecosystem.
2. Net primary productivity is equal to _____ _____
3. Remember: Gross primary productivity is _____ _____. Some of this glucose is used immediately by the plant in _____. The remaining glucose is _____ and is available to _____.
4. Net primary productivity is the most important measurement because it represents the amount of _____ that will be available to _____ in the ecosystem.
5. Net primary productivity _____ greatly from one _____ to another. For example, net primary productivity in a tropical rain forest is about _____ times greater than the net primary productivity in a desert of the same size.
6. Rain forests account for _____ of the Earth's surface, but account for _____ of the world's _____.
7. In terrestrial ecosystems, three factors determine the net primary productivity:
   a) _____
   b) _____
   c) _____

   An increase in these three factors generally leads to an increase in the amount of _____ taking place, and therefore, an increase in _____.

8. In aquatic ecosystems, productivity is limited by two factors:
   a) _____
   b) _____

F. Energy Transfer Between Trophic Levels
1. The amount of energy or matter in an ecosystem can be represented by an _____.
2. Ecological pyramid: _____
   _____
3. Roughly _____ of the total energy _____ in one trophic level is passed to the organisms in the _____.
4. The pyramid shape of the diagram below represents the low percentage of energy transfer from one trophic level to the next. Label each section of the ecological or energy pyramid.



5. Why is the transfer of energy to the next trophic level so low?
   a) Not all of the _____ possessed by the organisms at one trophic level will be _____ up to the next trophic level. Organisms _____ much of the energy they _____ for their own _____ such as respiration, movement, or reproduction.
   b) Many organisms at one trophic level will _____ by the _____ at the next level. The _____ of these "_____" will not be passed to the organisms at the _____ level.

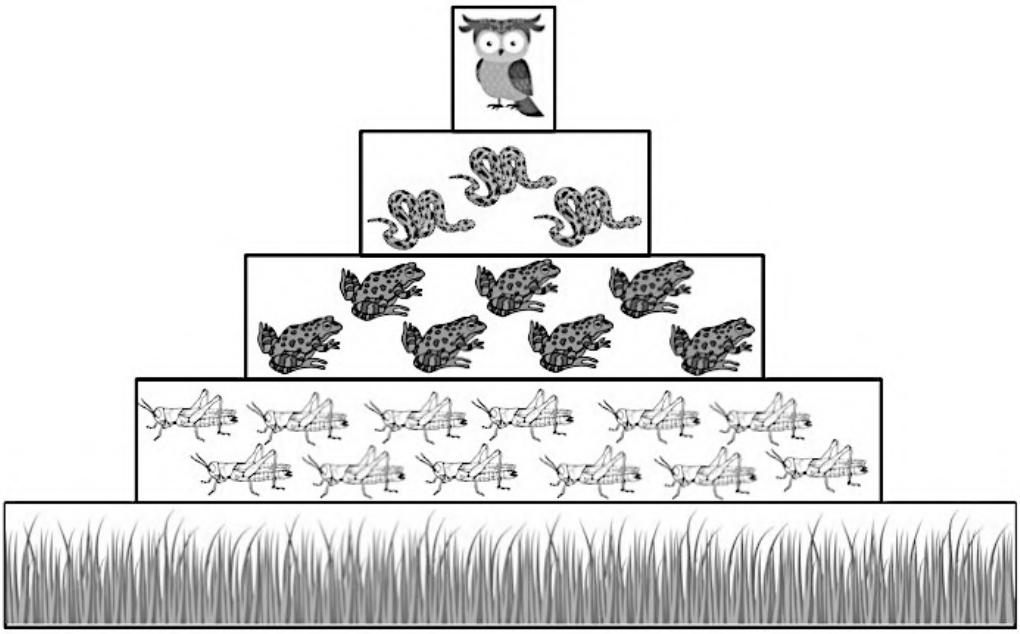
c) Even if the organism is _____, some of the molecules in its body will be in a form that the consumer cannot _____. An example might be the _____ of an antelope eaten by a lion.

d) Any energy consumed from _____ cannot be _____ to the next trophic level.

e) Finally, no energy transformation is _____ efficient. At each trophic level some energy will be lost to the environment in the form of _____.

6. Because each _____ receives only _____ of the energy from the trophic level _____, it can support only about _____ the amount of _____.

7. Label each section of the energy pyramid seen below.



If the energy content of the grass is approximately 5,000 calories per square meter of land surface, calculate the amount of energy that will be passed up to each trophic level.

8. The low rate of energy transfer between trophic levels explains why _____

_____

Organisms occupying the lower trophic levels are usually much more _____ than organisms belonging to the highest level. There are many more grasses, shrubs, and trees than there are _____. There are many herbivores (deer, antelope, gazelles) for each _____.

9. Higher trophic levels contain less _____, and therefore, they can support fewer _____.

IV. Ecosystem Recycling

A. Energy is crucial to an ecosystem, but the organisms need more than energy to survive. The organisms in the ecosystem also need _____.
For most organisms, more than _____of the body is made up of only four elements: _____. There is an _____ supply of these _____ on earth, but they must be in a form that _____ can take up.

B. Recycling in the Biosphere
1. _____ move through an ecosystem in very different ways.
2. Energy moves through an ecosystem in a _____. Energy enters an ecosystem in the form of _____ and exits the ecosystem in the form of _____. This energy _____.
3. Matter, however, is _____within and between _____.
4. Elements and compounds are recycled in _____.
A biogeochemical cycle connects the _____ aspects of the biosphere.

5. Biogeochemical cycle: _____

_____

_____

C. Types of biogeochemical cycles include:

1. _____
2. _____
3. _____
4. _____

V. The Water Cycle

A. Everyone knows that water is crucial to life. Living cells are _____ water. Water provides the environment in which most of the _____ of the cell occur.

B. At any given time, the water of earth can be found in the following places:

1. Bodies of water such as _____.
2. Stored in the bodies of _____.
3. In the atmosphere as _____.
4. Stored in underground formations as _____.
5. Oceans contain _____ of the water on earth. 2% is found in the _____ on earth. Only 1% of the water on earth is found in _____.

C. The movement of water between these various _____ is known as the_____.

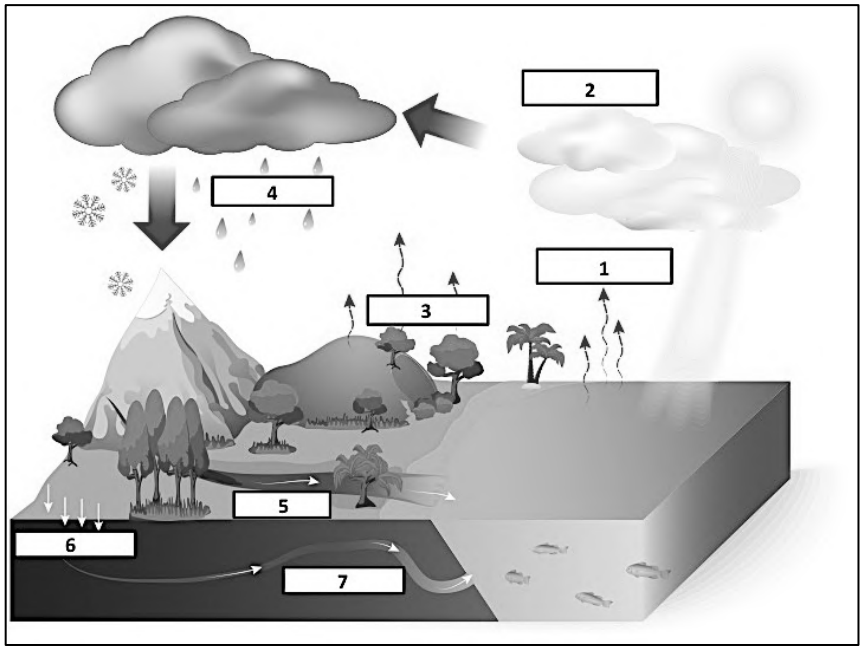
D. Four processes account for the movement of water molecules through the ecosystem:

1. _____
2. _____
3. _____
4. _____

E. Steps to the Water Cycle

Label each numbered section seen in the water cycle diagram to the right.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____



1. In the process of evaporation, _____ _____. _____ causes water molecules to _____ from bodies of water and from the bodies of living organisms.
2. _____ also adds molecules of water to the _____.
   Transpiration is _____.
   Water enters plants through the _____, and travels to the _____ of the plant. The leaves contain pores called _____ that open to take in _____ _____.
   When the stomata are open, molecules of water _____ from the leaf and enter the atmosphere.
3. The water vapor in the atmosphere _____ to form the _____. This is known as _____.
4. Animals also contribute _____ to the _____ but in a much less significant way than plants. Animals lose water when they _____ _____.
5. Water _____ the atmosphere and _____ through the process of _____. The atmosphere can only hold so much water vapor. The amount of water vapor in the atmosphere is dependent upon _____.
   Once the atmosphere becomes _____ with water vapor, it returns to the Earth in the form of _____.

VI. The Carbon Cycle

A. Carbon is the key _____ of all _____. All of the _____ _____.
   In order to build new organic compounds for living cells, there must be a constant and steady supply of available _____.

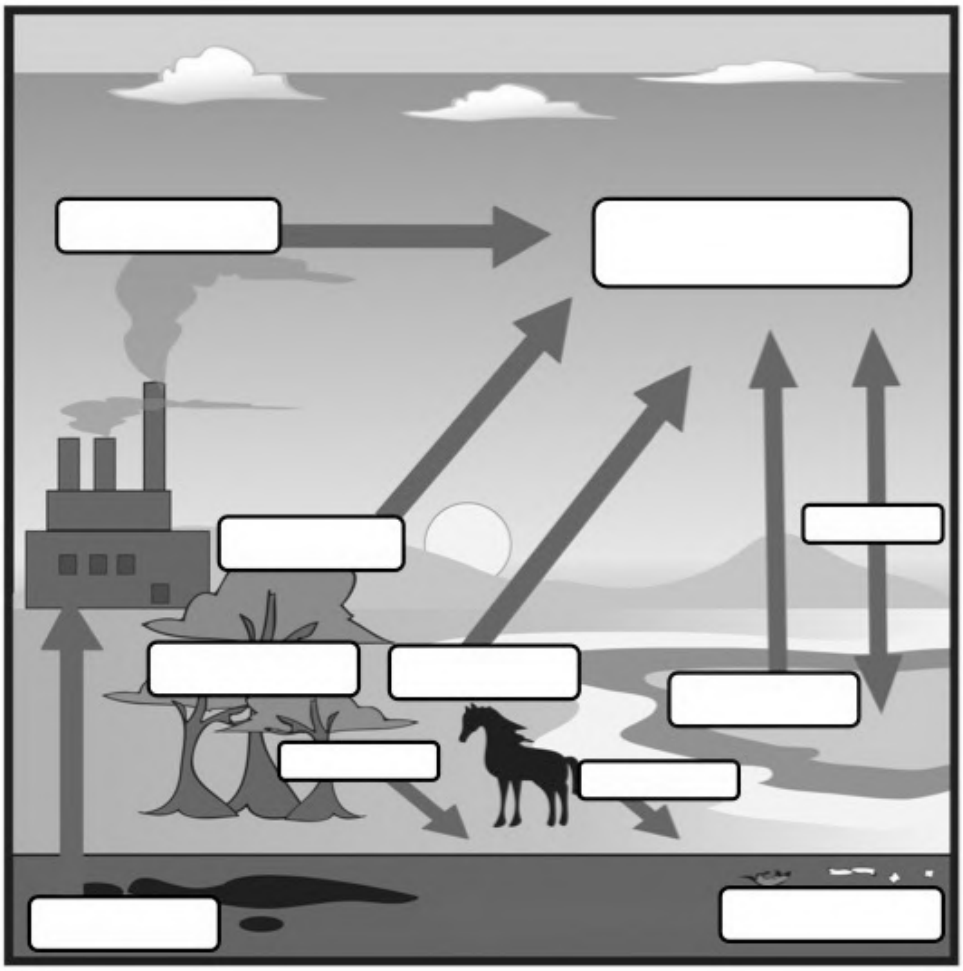
B. _____ form the basis of the carbon cycle. Carbon dioxide is taken in by _____ and used to build molecules of _____.
   Both autotrophs and heterotrophs carry out _____ in which the molecules of _____ are broken down into _____.
   Photosynthesis removes _____ from the atmosphere in the form of _____.
   _____ returns carbon dioxide back to the atmosphere.

C. Many types of processes move carbon through the ecosystem:

1. Photosynthesis _____.
2. Cellular respiration and decomposition _____.
3. Geochemical processes, such as _____, release carbon dioxide to the atmosphere and oceans.
4. Biogeochemical processes cause dead organisms to _____. Under pressure, their bodies are converted into coal and petroleum (fossil fuels). This stores _____.
5. Human activities, such as _____
   _____

D. Steps in the Carbon Cycle

Label the steps of the carbon cycle in the diagram below:



1. In the _____, carbon is present in the form of _____.
2. This carbon dioxide is released to the atmosphere by _____

   _____
3. Plants (_____) take in the carbon dioxide and use it during _____ to build molecules of _____.
4. The glucose molecules and other carbohydrates are _____ to animals and other consumers.
5. The _____ also serves as a storage area for _____. Many marine organisms combine carbon, calcium and oxygen to form _____. This calcium carbonate accumulates in marine sediments and in the _____ of many marine organisms. Eventually these compounds break down and the carbon returns to the atmosphere.

E. The Human Impact on the Carbon Cycle

1. In the last 150 years, the concentration of _____ in the atmosphere has _____ dramatically. Most of this increase has occurred in the last 40 years. The activities of _____ are responsible for this huge increase in atmospheric carbon dioxide.
2. Our industrial society depends on the energy that comes from _____

   _____

   But the burning of these fossil fuels _____ the amount of carbon dioxide entering the atmosphere.
3. Life on Earth depends on the "_____". Carbon dioxide, water vapor and other gases _____. This _____ the Earth and _____ it from the deep cold of space.
4. However, the _____ of carbon dioxide also _____ the greenhouse effect. Today, _____ is being trapped by the atmosphere and this has led to the current period of _____.

VII. The Nitrogen Cycle

A. All organisms must have nitrogen in order to build _____.

B. Nitrogen gas makes up about _____ of Earth's _____. It would appear that nitrogen is _____ for use in manufacturing proteins and amino acids. However, most organisms _____ to make use of atmospheric nitrogen.

C. Nitrogen is also found in _____

_____.

D. The nitrogen cycle is possible only because of several different types of _____. Each type of bacteria plays a particular role in the recycling of nitrogen.

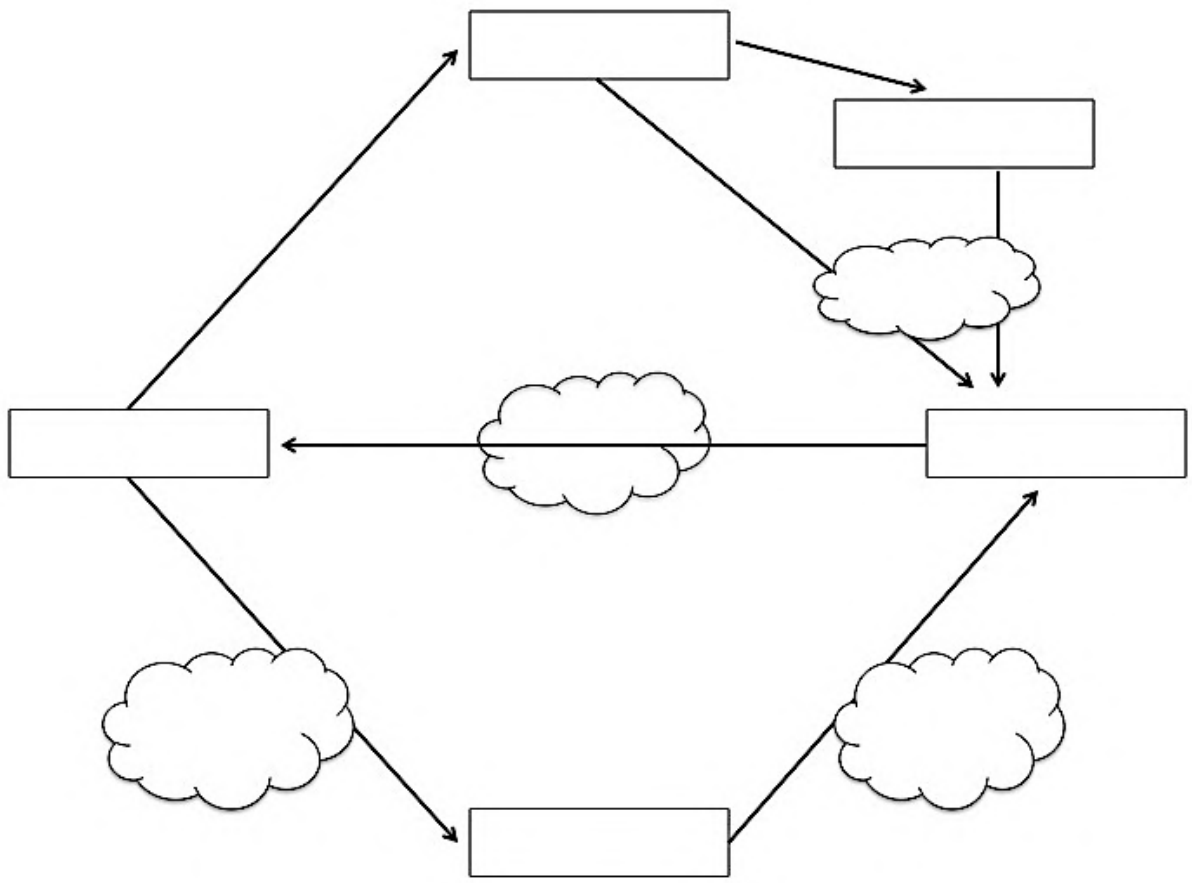
E. Nitrogen Fixation

1. A special group of soil-dwelling bacteria, known as _____, are able to _____.
2. These bacteria _____.
3. Nitrogen Fixation: _____
4. The nitrates are absorbed _____.

   Plants use nitrates to build _____.
5. The nitrogen is then passed _____.

F. Steps of the Nitrogen Cycle

Fill in the diagram as the steps below are being discussed.



The nitrogen cycle is a complex cycle with five important processes:

1. Nitrogen Fixation: _____

   _____

2. Ammonification
   a) Many animals excrete and eliminate nitrogen in _____.

      Soil bacteria convert these waste products into _____. In addition, these

      bacteria convert the nitrogen compounds in _____ to ammonia.
   b) Some of this ammonia is absorbed by _____ and used to make

      _____.
   c) Ammonification is _____

      _____

3. Nitrification
   a) Some of the _____ in the soil is converted by several kinds of bacteria to

      _____.
   b) These nitrates are absorbed from the soil by _____.
   c) Nitrification is _____.

4. Denitrification
   a) Another kind of bacteria acts on _____

      _____.
   b) This _____ is released into the _____.
   c) Denitrification is _____.

5. Assimilation
   a) _____
   b) Plants use _____ to build proteins and nucleic acids.
   c) When animals _____ the plants, they use the nitrogen to build _____

      _____.
   d) Nitrogen assimilation _____

      _____.

G. The nitrogen cycle requires _____.

What is the role of each of the following groups of bacteria?

1. Nitrogen – fixing bacteria: _____

   _____

2. Ammonifying bacteria: _____

   _____

3. Nitrifying Bacteria: _____

   _____

4. Denitrifying bacteria: _____

   _____

VIII. The Phosphorus Cycle

A. Phosphorus is essential in all living organisms because it is needed to _____

   _____.

B. Although phosphorus is of great biological importance, it is _____ in the biosphere.

C. Unlike the other essential elements that are recycled such as carbon, nitrogen, and oxygen, phosphorus does not enter the _____.

D. Phosphates are usually present in rocks and soil as _____.

   Calcium phosphate dissolves in water to form inorganic _____. As phosphates are released from _____, it washes into streams and rivers, eventually making its way to the _____ where it is used by _____.

E. Some phosphates remain on land and cycle between _____ and the _____.

F. When _____ absorb phosphate from the soil or from water, they bind the phosphate into _____. The phosphate moves through the _____ from producers to consumers.

IX. Nutrient Limitation

A. As we have already learned above, primary productivity is _____

_____

A factor that determines the primary productivity of an ecosystem is _____

_____.

B. Limiting nutrient: _____

_____

_____